Claims

1. A probe head for use with a spectrometer to analyze a material, the probe head comprising:

a light source arranged to irradiate a sample volume of the material proximate the probe head,

an optical pick-up arranged to receive light emitted from the irradiated sample volume and transmit the emitted light to the spectrometer for analysis,

an optical blocking element positioned in the optical path between the light source and the optical pick-up to force the optical path into the sample volume, and

a reference shutter for selectively blocking light emitted from the irradiated sample volume from reaching the optical pick-up to facilitate calibration of the spectrometer.

2. The probe head of claim 1, further comprising a housing having a sample window proximate the sample volume, the light source irradiating the sample volume through the sample window, the sample window transmitting light emitted from the sample volume to the optical pick-up.

3. The probe head of claim 2, wherein the optical blocking element is biased into contact with the sample window.

4. The probe head of claim 1, wherein the optical blocking element is opaque.

5. The probe head of claim 1, wherein the reference shutter is movable between a closed position that blocks light emitted from the sample volume from reaching the optical pick-up and an open position that permits light emitted from the sample volume to reach the optical pick up.

6. The probe head of claim 5, wherein movement of the reference shutter from the open position to the closed position causes the optical blocking element to move out of contact with the sample window.

7. The probe head of claim 1, wherein the reference shutter includes a reference surface having a uniform reflectance value to facilitate calibration of the spectrometer.

8. A method of spectroscopically analyzing a material comprising:

irradiating a sample volume of the material with light from a light source,

transmitting light emitted from the irradiated sample volume to an optical pick up that is optically connected to a spectrometer,

forcing an optical path between the light source and the optical pick-up into the sample volume, and

selectively blocking light emitted from the irradiated sample volume from reaching the optical pick-up to facilitate calibration of the spectrometer.

9. The method of claim 8, wherein the step of forcing the optical path includes blocking light reflected from a sample window within the optical path from reaching the optical pick-up.

10. The method of claim 8, wherein the step of selectively blocking light includes selectively moving a reference shutter into the optical path to block light emitted from the irradiated sample volume from reaching the optical pick-up.

11. A probe head for use with a spectrometer to analyze a material, the probe head comprising:

a housing having a first chamber separated from a second chamber,

a light source disposed in the first chamber and arranged to irradiate a sample volume of the material with a plurality of wavelengths of light,

a wavelength separator disposed in the second chamber, the wavelength separator receiving light reflected from the irradiated sample volume to produce spatially separated light of different wavelengths, and

a detector connected to the spectrometer, the detector being disposed in the second chamber and positioned to receive the spatially separated light from the wavelength separator, the detector transmitting a signal to the spectrometer representative of the intensity of the spatially separated light received from the wavelength separator.

12. The probe head of claim 11, wherein the first chamber of the housing includes a first window and the light source irradiates light through the first window onto a sample volume.

13. The probe head of claim 12, wherein the second chamber of the housing includes a second window and the wavelength separator receives light through the second window from the irradiated sample volume.

14. The probe head of claim 11, wherein the detector in the second chamber is hermetically sealed.

15. The probe head of claim 14, further comprising a reflector positioned in the housing to reflect a portion of light emanating from the light source into the second chamber for calibration measurements.

16. The probe head of claim 11, further comprising a reference shutter for selectively blocking light emitted from the irradiated sample volume from reaching the detector to facilitate calibration of the spectrometer.

17. The probe head of claim 11, wherein the light source irradiates the sample volume with light in a visible to mid infrared spectral region.

18. The probe head of claim 11, further comprising a diffuser for diffusing light reflected from the irradiated sample volume into the wavelength separator.

19. The probe head of claim 11, wherein color components of the sample volume are determined based on intensities of the wavelengths of the spatially separated light received by the detector.

20. The probe head of claim 11, wherein the detector has a viewing aperture greater than about 0.5 square inches.

21. The probe head of claim 11, wherein the detector has a viewing aperture between about 0.5 square inches and about 10 square inches.

22. The probe head of claim 11, wherein the light source illuminates a spot size greater than about 0.5 square inches.

23. The probe head of claim 11, wherein the light source illuminates a spot size between about 0.5 square inches and about 10 square inches.

24. The probe head of claim 11, further comprising an optical blocking element positioned in an optical path between the light source and the detector to force the optical path into the sample volume

25. A spectrometer for analyzing a material, the spectrometer comprising:

a probe head comprising

a housing having a first chamber separated from a second chamber,

a light source disposed in the first chamber arranged to irradiate a sample volume of the material with a plurality of wavelengths of light,

a wavelength separator disposed in the second chamber, the wavelength separator receiving light reflected from the irradiated sample volume to produce spatially separated light of different wavelengths, and

a detector disposed in the second chamber and positioned to receive the spatially separated light from the wavelength separator, the detector generating a signal representative of the intensity of the spatially separated light received from the wavelength separator, and

a computer coupled to the detector and housed separately from the probe head, the computer receiving the signal generated by the detector and analyzing the sample volume based on the signal.

26. The spectrometer of claim 25, further comprising an analog to digital converter coupled to the detector and the computer, the analog to digital converter converting the signal from the detector from an analog signal to a digital signal for receipt by the computer.

27. The spectrometer of claim 25, wherein the housing of the probe head is configured for positioning in a sample containment apparatus to monitor a material flowing through the sample containment apparatus.

28. A method of spectroscopically analyzing a material with a spectrometer, the method comprising:

irradiating a sample volume of the material with a plurality of wavelengths of light from a light source positioned in a first chamber,

receiving light reflected from the irradiated sample volume in a second chamber,

separating wavelengths of the received light to produce spatially separated light of different wavelengths, and

detecting intensity of the spatially separated light with a detector positioned in the second chamber and connected to the spectrometer.

29. The method of claim 28, further comprising the step of selectively reflecting a portion of light emanating from the light source into the second chamber for calibration measurements.

30. The method of claim 28, wherein light from the light source is within a visible to mid infrared spectral region.

31. The method of claim 28, further comprising the step of diffusing light reflected from the irradiated sample volume.

32. The method of claim 28, further comprising the step of determining constituent components of the sample volume based on the detected intensity.

33. The method of claim 28, further comprising the step of determining color components of the sample volume based on the detected intensity.

34. The method of claim 28, wherein the light source illuminates a spot size greater than about 0.5 square inches.

35. The method of claim 28, wherein the light source illuminates a spot size between about 0.5 square inches and about 10 square inches.

36. The method of claim 28, wherein the detector has a viewing aperture greater than about 0.5 square inches.

37. The method of claim 28, wherein the detector has a viewing aperture between about 0.5 square inches and about 10 square inches.

38. The method of claim 28, further comprising the step of forcing an optical path between the light source and the detector into the sample volume.

39. A method of spectroscopically analyzing a material with a spectrometer, the method comprising:

irradiating a sample volume of the material with a plurality of wavelengths of light having a spot size of greater than about 0.5 square inches,

separating wavelengths of the light reflected from the sample volume to produce spatially separated light of different wavelengths, and

detecting intensity of the spatially separated light with a detector coupled to the spectrometer and having a viewing aperture of greater than about 0.5 square inches.

40. The method of claim 39, wherein the light has a spot size between about 0.5 and about 10 square inches.

41. The method of claim 39, wherein the detector has a viewing aperture between about 0.5 square inches and about 10 square inches.

42. A method of spectroscopically analyzing a material flowing within a sample containment apparatus, the method comprising:

positioning a probe head of a spectrometer on the sample containment apparatus,

irradiating a sample volume of the material within the sample containment apparatus with a plurality of wavelengths of light from a light source positioned in a first chamber of the probe head,

receiving light reflected from the irradiated sample volume in a second chamber of the probe head,

separating wavelengths of the received light to produce spatially separated light of different wavelengths, and

detecting intensity of the spatially separated light with a detector positioned in the second chamber.